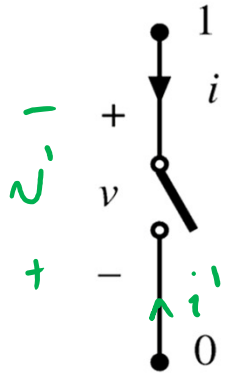
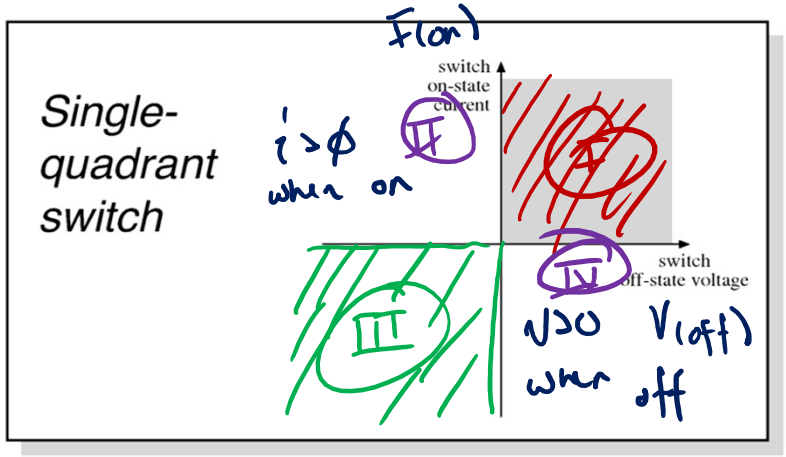
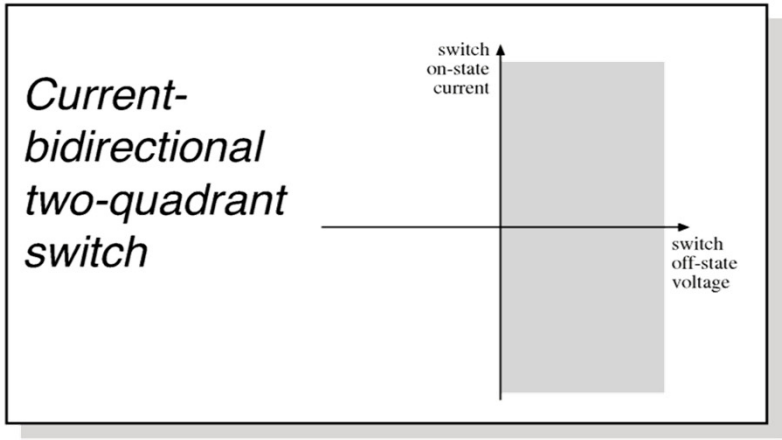
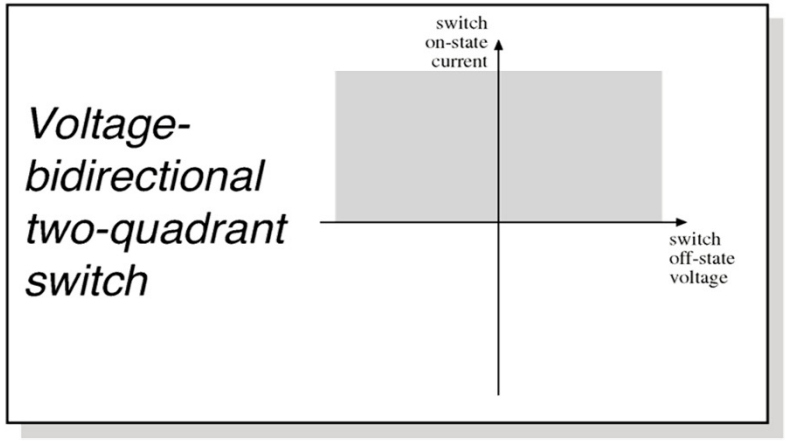
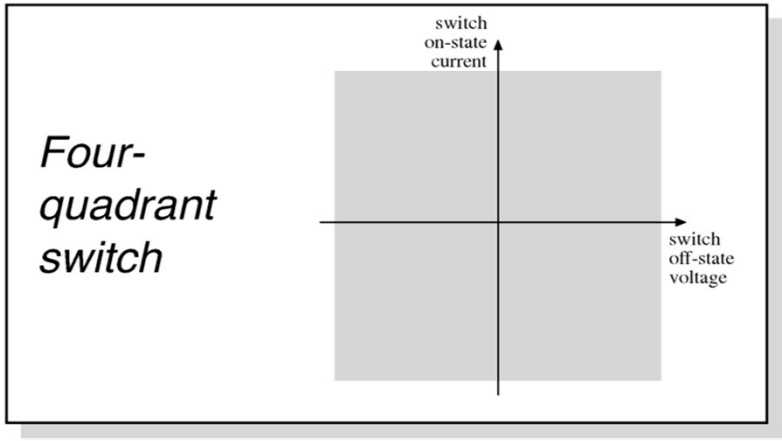
SPST Operating Quadrants



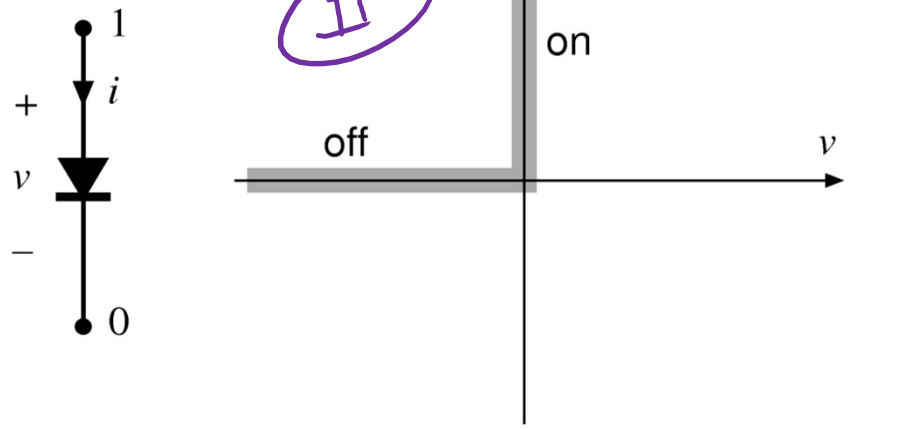








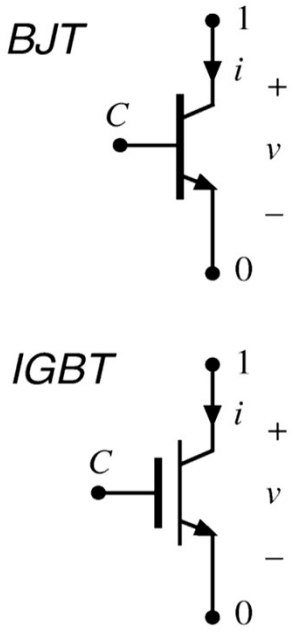
The Diode

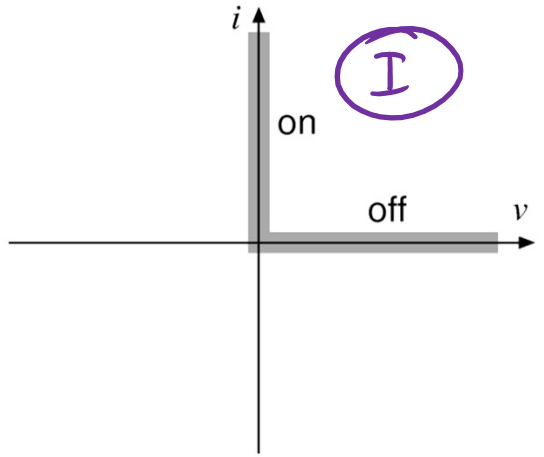


Symbol *instantaneous i-v characteristic*

- *A passive switch*
- *Single-quadrant switch:*
- *can conduct positive on-state current*
- *can block negative off-state voltage*
- *provided that the intended on-state and off-state operating points lie on the diode i-v characteristic, then switch can be realized using a diode*

(Insulated Gate) Bipolar Junction Transistor

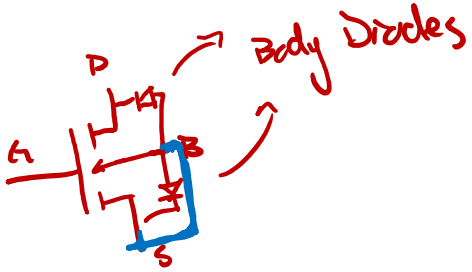


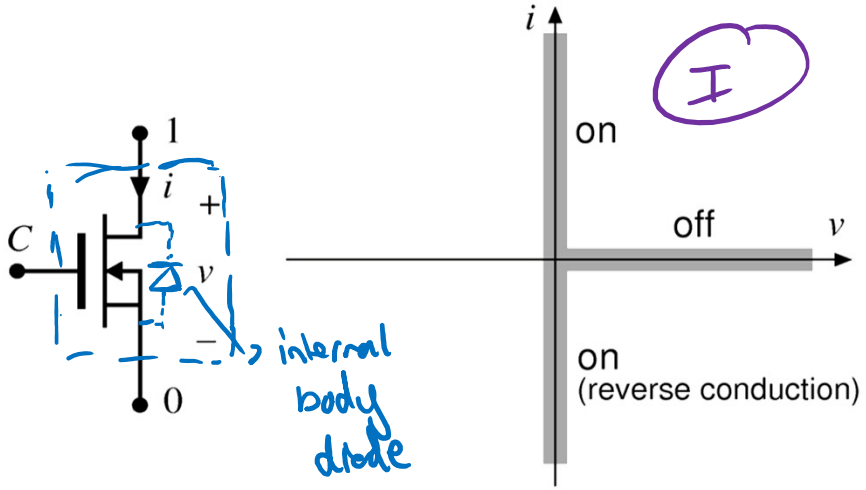


instantaneous i-v characteristic

- *An active switch, controlled by terminal C*
- *Single-quadrant switch:*
- *can conduct positive on-state current*
- *can block positive off-state voltage*
- *provided that the intended on-state and off-state operating points lie on the transistor i-v characteristic, then switch can be realized using a BJT or IGBT*

MOSFET

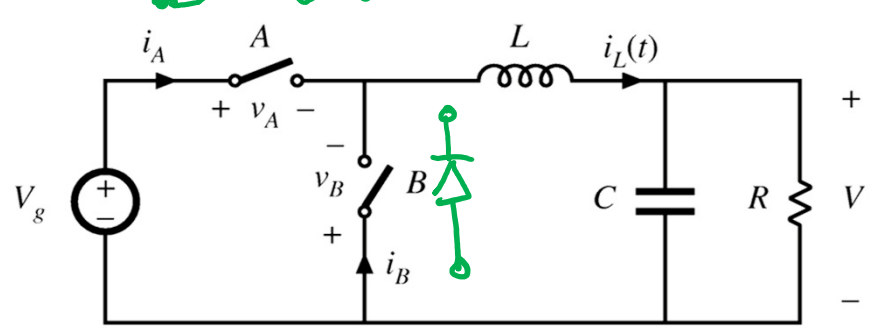




Symbol *instantaneous i-v characteristic*

- *An active switch, controlled by terminal C*
- *Normally operated as single-quadrant switch:*
- *can conduct positive on-state current (can also conduct negative current in some circumstances)*
- *can block positive off-state voltage*
- *provided that the intended on-state and off-state operating points lie on the MOSFET i-v characteristic, then switch can be realized using a MOSFET*

Buck Converter: Switch Realization



From previous:

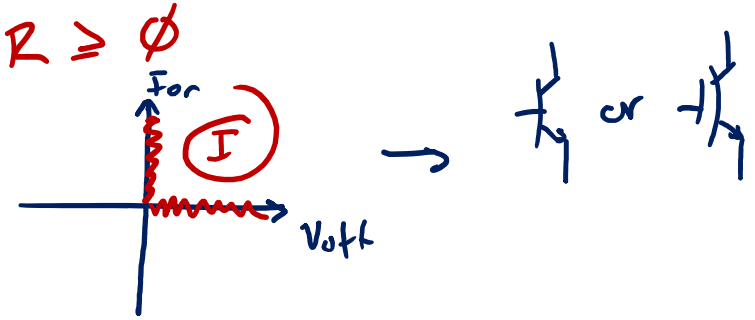
$V = DV_g$

$I_L = \frac{V}{R}$

Can always use $V_g > \phi$, $0 \le D \le 1$, $R \ge \phi$

(A) $V_{off} = V_g > \phi \rightarrow V_{off} > \phi$

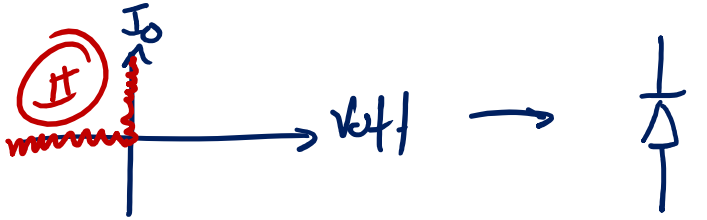
$I_{on} = I_L = \frac{V}{R} = \frac{DV_g}{R} > \phi \rightarrow I_{on} > \phi$



→ or

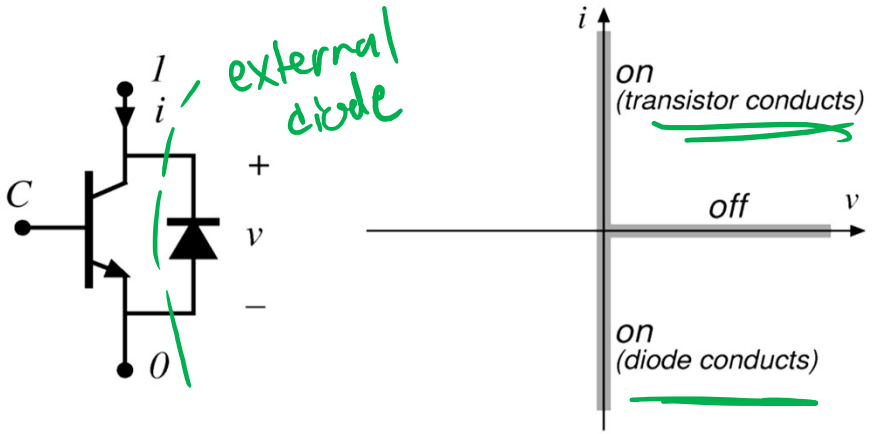
(B) $V_{off} = -V_g < \phi \rightarrow V_{off} < \phi$

$I_{on} = I_L = \frac{V}{R} = \frac{DV_g}{R} > \phi \quad I_{on} > \phi$



→

Current Bidirectional Two-Quadrant

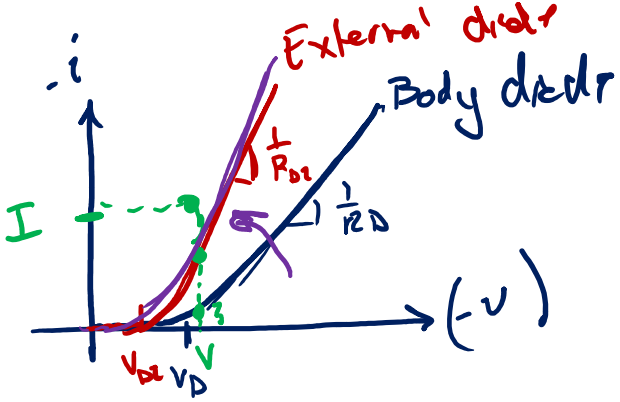


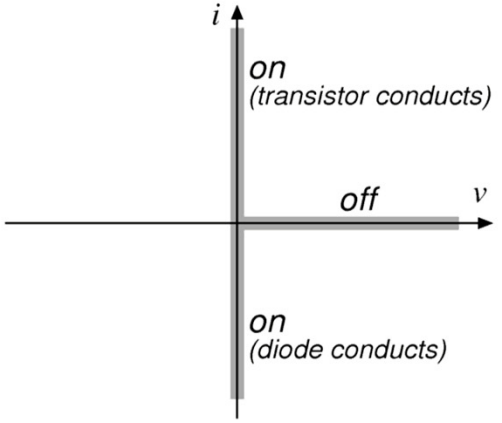
BJT / anti-parallel diode realization

instantaneous i-v characteristic

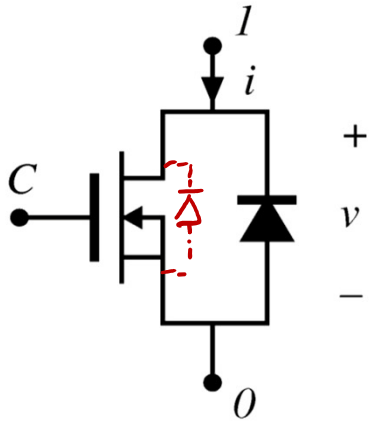
- *Usually an active switch, controlled by terminal C*
- *Normally operated as two-quadrant switch:*
- *can conduct positive or negative on-state current*
- *can block positive off-state voltage*
- *provided that the intended on-state and off-state operating points lie on the composite i-v characteristic, then switch can be realized as shown*

MOSFET Body Diode

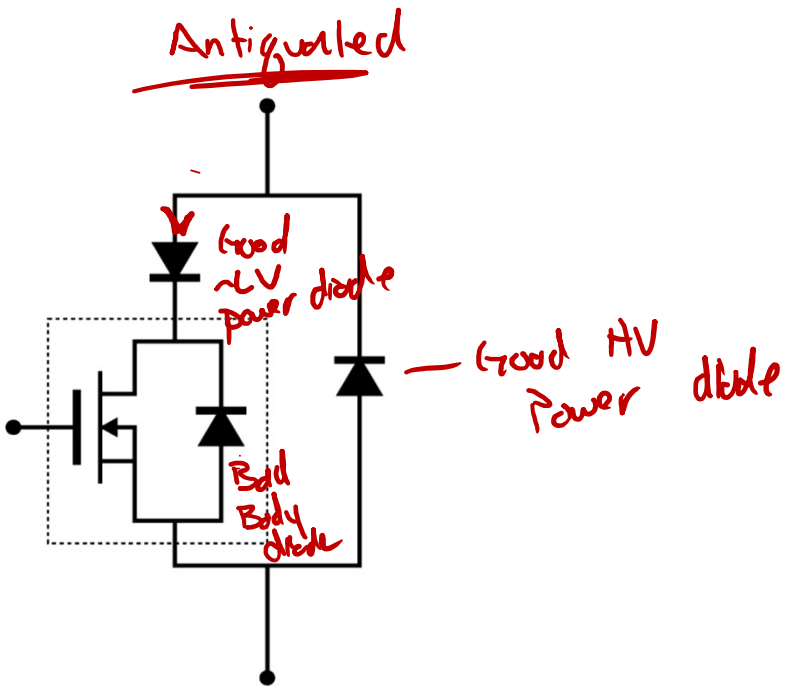




Power MOSFET characteristics

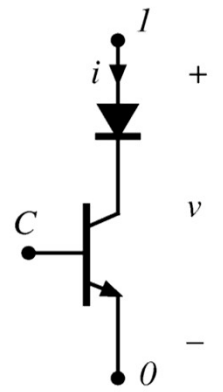


Power MOSFET, and its integral body diode

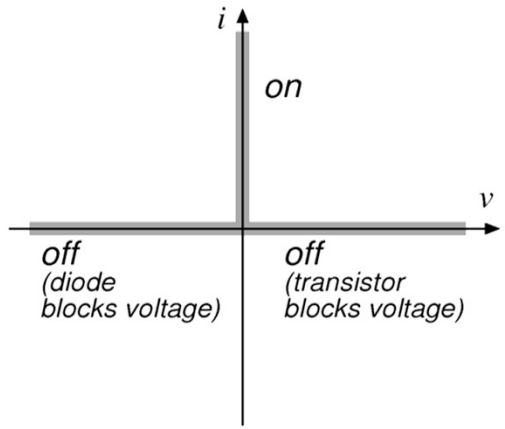


Use of external diodes to prevent conduction of body diode

Voltage-bidirectional Two-Quadrant



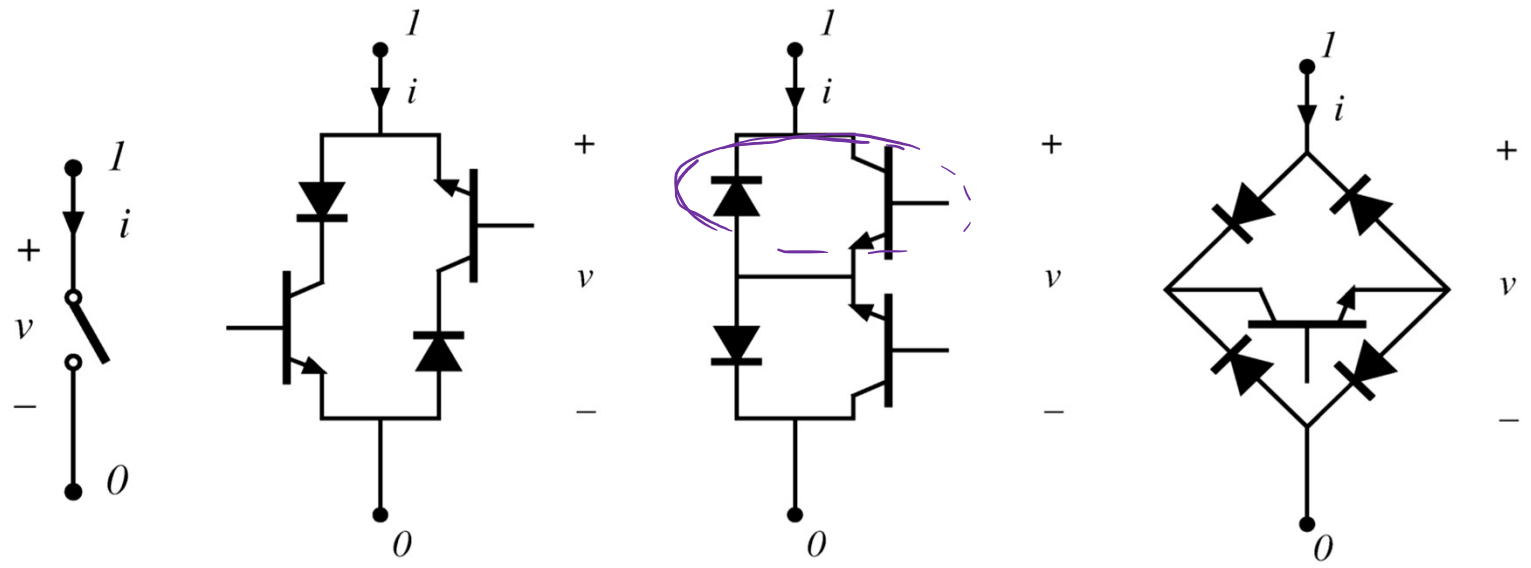
BJT / series diode realization



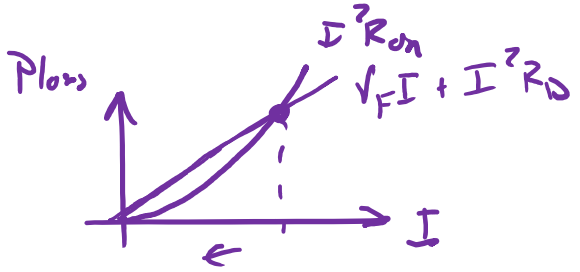
instantaneous i-v characteristic

- *Usually an active switch, controlled by terminal C*
- *Normally operated as two-quadrant switch:*
- *can conduct positive on-state current*
- *can block positive or negative off-state voltage*
- *provided that the intended on-state and off-state operating points lie on the composite i-v characteristic, then switch can be realized as shown*
- *The SCR is such a device, without controlled turn-off*

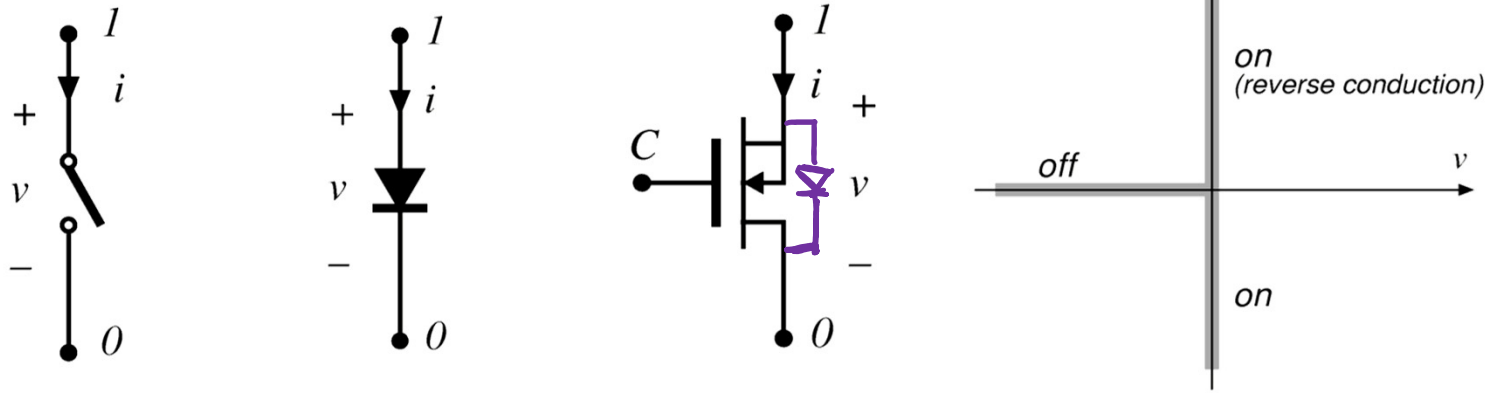
Four-Quadrant Switches



Synchronous Rectifiers



Replacement of diode with a backwards-connected MOSFET, to obtain reduced conduction loss



ideal switch | *conventional diode rectifier* | *MOSFET as synchronous rectifier* | *instantaneous i-v characteristic*